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CONTENTS

page

1. G. Unterstenhöfer:
GUSATHION, a new polyvalent insecticide and acaricide 81

2. A. Becker:
On the question of storing treated and wet grain seed 90

3. P. E. Frohberger:
Studies on the question of the influence of seed treatment and water content of grains on latter's storage property 103

4. Gideon Ting-wei Lew:
Pineapple Mealybug Control in Taiwan 114

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BAYER LEVERKUSEN (GERMANY)
Department for Crop Protection

GUSATHION®,*
a new polyvalent insecticide and acaricide**

by G. Unterstenhöfer, Leverkusen

Infestation of cultivated plants by insect pests often extends over lengthy periods due to intermittent flight, gradual migration and drift or to variations in the period of embryonic development brought about by microclimatic conditions, which often leads to considerable time deviations in hatching. To control pests under such conditions means that applications of active substances with a limited residual effect have to be repeated or else a single application must be made of a product having an adequately long residual effect; this latter alternative is of course more preferable from the economic aspect. Systemic insecticides developed from the group of organophosphorus compounds (SYSTOX®, METASYSTOX®, DISYSTON®) possess the properties required of a product for controlling such sucking pests as aphids and spider mites, in that they immunize the treated plants for a certain period. As a result, completely new possibilities have been opened up for the control of these pests, which in the case of aphids have become of great importance for preventing yield losses caused by persistent viruses. Organophosphorus compounds are also available for the control of fruit pests; these products feature a good residual effect so essential for controlling codling moth, grape berry moth and sawfly. The most outstanding member of this particular group is E 605®. We believed, however, that it was most important to develop from the same group of phosphorus compounds an active substance which remains effective for a lengthy period also on the surface of the plant; in other words, a product lacking the translaminar effect characteristic of many phosphorus esters, and which in its properties and mode of action is similar to the persistent chlorinated hydrocarbons. Such a product must have as wide a range of action as possible because in the treatment of crops like fruit, grape vines, cotton, citrus etc. that require intensive protection, several pest species have to be controlled in one operation. It was expected that thorough research would provide a solution to the problem. The necessity of concentrating on the phosphorus esters in the search for active substances possessing the described properties, is due to the fact that there is a marked tendency for pests to develop strains resistant to chlorinated hydrocarbons; an outstanding example of this is *Anthonomus grandis*.

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* Marketed under the trade-name "GUTHION®" in the U. S. A.

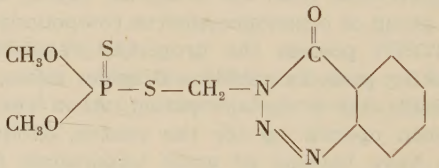
** Abridged version read at the 10th International Symposium on Plant Protection at Gent, May 6—7, 1958.

® = Registered trade-mark of Farbenfabriken Bayer Aktiengesellschaft.

We believe that through the development of GUSATHION — its characteristic properties are discussed in the following chapters — we can for the present regard the task we set ourselves as having been fulfilled. This compound, which has been tested on the widest possible scale, has already established itself as a most reliable and effective insecticide and acaricide for controlling cotton pests, and there are very good prospects of it proving to be most useful in fruit and citrus farming. Even though our knowledge of the possible uses of GUSATHION is by no means complete, and as new fields of application are constantly being discovered, such properties as effect, mechanism of action and secondary effects on which the assessment of a compound's suitability for crop protection purposes is based, have been examined so thoroughly that a description of this product can be given.

I. Chemical and physical properties:

According to the chemical constitution, the product GUSATHION synthesized by Dr. Lorenz at the Crop Protection Laboratory of Farbenfabriken Bayer Aktiengesellschaft (head of this laboratory is Dr. G. Schrader) has the definition 0,0-dimethyl-S-(benzaziminomethyl)-dithiophosphate. The essential properties are as follows:



Molecular weight:	317	Melting point:	73—74° C
Specific gravity:	$d_4^{20} \times 1{\cdot}44$	Vapour pressure:	So low that it is practically immeasurable at room temperature.
Refractive index:	n_D^{76} 1·6115		

II. Toxicity:

1. Acute toxicity:

A detailed paper on the toxicity and pharmacological actions of GUSATHION was published in 1957 by DuBois, Thursh and Murphy (1). The most outstanding values obtained in their studies are as follows:

		LD_{50}
Intraperitoneal:	rat ♂	11·6 mg/kg
	♀	5·7 mg/kg
	mouse ♂	5·4 mg/kg
	♀	3·4 mg/kg
	guinea pig ♂	40·0 mg/kg
Per os:	rat ♀	16·4 mg/kg
	guinea pig ♂	80·0 mg/kg

according to Du Bois, Thursh and Murphy (1957).

2. Subacute (chronic) toxicity:

Rats tolerate relatively high quantities at the acute toxicity level, when these are administered in daily dosages. Over a period of 60 days, dosages of 0·5 and 1 mg of active substance per kilo body weight were administered intraperitoneally but the treated rats did not die. In the tests conducted by Du Bois and co-workers, the symptoms caused by GUSATHION were the same in all species tested, and characteristic of cholinergic drugs. Atropine has a marked antagonistic action.

Fig. 1

III. Insecticidal and acaricidal properties:

1. Resorption:

The mechanism of action as facilitated in a particular form of resorption, i. e. whether GUSATHION is essentially a stomach, contact or breathing poison or constitutes a combination of the different mechanisms, was investigated by us on house flies *(Musca domestica);* the reason for using house flies was that proved working techniques already exist for this particular species. The stomach poison effect was determined by applying exactly dosed drops of a combined solution of active substance and sugar water by means of a micro injection

syringe to the proboscis tips of flies fixed on their backs on slides (Fig. 1); for determining the contact poison effect, the same appliance was used to apply exactly dosed quantities of active substance-acetone solutions to the ventral side on the abdomen of narcotized flies. The breathing poison effect was studied in hydrostats; here, the flies were placed above a deposit of active substance in such a way that they could not come into direct contact with this deposit. The results obtained are given below.

Form of resorption for flies		
Contact poison effect	Stomach poison effect	Breathing poison effect
0·07 µg fly	0·05 µg fly	100 mg/Petri dish (hygrostat)
5·3 mg/kg fly	3·7 mg/kg fly	no effect

Corresponding to its very low vapour pressure, GUSATHION does not have a determinable effect on flies in the gas phase. On the other hand, it does produce a contact effect and a stomach poison effect. Insofar as importance can be attached to the registered differences, the stomach poison effect is the somewhat stronger of the two. An interesting fact is that these values fully conform with the intraperitoneal data obtained for mice and female rats. Exact studies carried out with the micro injection and sandwich methods on *Agrotis segetum* also showed that the stomach poison and contact poison effects are greatly similar with values around 50 mg/kilo. This finding is also confirmed by the results of tests on spider mites, namely that GUSATHION does not produce an effect in the gas phase but that it has a combined contact poison and stomach poison effect so that these two mechanisms can be regarded as the main forms of resorption.

2. Stage-specificity

GUSATHION is toxic to adult insects, larvae and eggs. The susceptibility of the different stages of insect development varies among the different species. A marked ovicidal effect and a larvicidal effect were obtained against *Carpocapsa pomonella.*

3. Translaminar and systemic effect

In exhaustive biological experiments on aphids, codling moth larvae concealed in mines bored into fruit, and mangold fly (spinach leaf miner) larvae, it was established that GUSATHION does not have a systemic effect and only a very slight translaminar action (penetration into the plant tissue such as is so characteristic of E 605); on the contrary, this product when applied remains essentially on the treated plant surface. These findings were confirmed by Tietz, Metcalf and Fukuto (2) with the aid of paper-chromatographic analyses carried out during their studies on the action of this product on cotton plants. We have experienced that these properties are in line with the chemical constitution and the physical properties of the compound.

4. Residual effect

The residual effect now given by GUSATHION is one of its most outstanding properties. With a dosage of 0·02 %, a residual effect of 21 days was registered in tests against the potato beetle *(Leptinotarsa decemlineata),* and one of 15 days against *Lymantria dispar.* In trial controls of common winter-

moth *(Cheimatobia brumata)*, GUSATHION gave a 70 % kill after 13 days; this constituted a residual effect which was considerably more persistent than the effects produced with the conventional organophosphorus compounds, and equal to the best residual effects given by chlorinated hydrocarbons included in these tests as comparison products. These findings fully conform with the results obtained on cotton, first published by Ivy and co-workers (3) in 1955. It is also stressed in papers published by Ruffin (4) and Rainwater (5) on the effect given against cotton insects in general and against boll weevil in particular, that GUSATHION is a stable compound which remains effective for a lengthy period, thus reducing the number of control operations otherwise necessary. Rainwater (5) pointed out that the residual effect of GUSATHION enables controls to be carried out at weekly intervals when this compound is used, whereas other products have to be sprayed every five days.

As the residual effect of ectotherapeutic compounds — apart from the resistance to mechanical influences, in particular rain — very largely depends upon resistance to light, or rathermore ultra-violet rays, exhaustive studies were conducted on the absorption bands of GUSATHION. It was established that the compound is practically unaffected by light. Similar findings were made by Mistric and Martin (6) in their studies on the effect of sunlight and other factors on the toxicity of insecticides in general and GUSATHION in particular.

5. Range of action and insecticidal potency

		LD_{50}	LD_{95}
Granary weevil	*Calandra granaria*	0·01 %	0·06 %
Potato beetle	*Leptinotarsa decemlineata*	0·006 %	—
Gypsy moth	*Lymantria dispar*	0·002 %	0·01 %
Diamond-back moth	*Plutella maculipennis*	0·0007 %	0·001 %
Common lackey moth	*Malacosoma neustria*	0·0006 %	—
Browntail moth	*Euproctis chrysorrhoea*	0·0009 %	—
Cabbageworm	*Agrotis segetum*	0·03 %	—
Imported cabbageworm	*Pieris brassicae*	0·0008 %	—
	Pieris rapae	0·0007 %	—
	Mamestra oleracea	0·01 %	—
House fly	*Musca domestica*	0·01 %	—
House fly larvae	*Musca domestica*	—	0·0008 %
Mosquito larvae	*Aedes aegypti*	0·000006 %	—
Black bean aphid	*Doralis fabae*	0·0001 %	0·0009 %
Peach-potato aphid	*Myzodes persicae*	0·006 %	0·01 %
Common spider mite	*Tetranychus telarius*		
normally susceptible		—	0·0008 %
resistant		—	0·004 %

In the very first screening test, GUSATHION showed that it features a high insecticidal and acaricidal potency, and has a wide range of action. The following table gives an indication of this; the listed values originate from laboratory tests carried out to determine toxic data.

A study of the tabulated values shows the outstanding features to be the high effect against biting insects, especially Lepidoptera larvae, with a good effect against sucking pests, on the one hand, and the pronounced acaricidal potency with a strikingly favourable relation between the effect on normally susceptible mites and against mite strains resistant to phosphorus compounds, on the other hand. Judging by previous findings and in view of the present state of the resistance problem, the latter condition appears to be a characteristic of many esters of dithiophosphoric acid. In 1955, Ivy et al. (3) reported on the ranges of action of GUSATHION (17 147) and its homologous diethyl ester (16 259) against major cotton insects, and thus confirmed the fundamental findings that these compounds have a wide range of action.

	16 259 Ethyl-Gusathion	17 147 Gusathion
Anthonomus grandis	0·25 lb/acre 90%	0·25 lb/acre 100%
Aphis gossypii	0·125 lb/acre 100%	0·125 lb/acre 75%
Tetranychus tumidus	0·062 lb/acre 100%	0·5 lb/acre 97%
Heliothis armigera	—	2·0 lb/acre 90%
Alabama argillacea	1·0 lb/acre 100%	0·5 lb/acre 100%
Acontia dacia	—	0·5 lb/acre 100%
Estigmene acrea	1·0 lb/acre 74%	1·0 lb/acre 15%
Psallus seriatus	—	0·062 lb/acre 100%
Pectinophora gossypiella	—	2·0 lb/acre 81%

The high insecticidal potency of GUSATHION against cotton pests and this product's long residual effect are features that have been established beyond doubt in numerous tests especially in cottonfields of the northern and middle states of the U. S. A. Following the excellent results obtained in all tests, the product was registered in the U. S. A. in 1956 as a cotton insecticide for controlling boll weevil, spider mite, thrips, aphid, cotton fleahopper and a number of caterpillar species (garden webworm, brown cotton leafworm, cotton leafworm, pink bollworm, cotton leaf perforator, bollworm). Of special importance is the reference made by Rainwater (5) that GUSATHION is effective also against resistant populations of the boll weevil. It was proved that the toxic values are practically identical for both resistant and normally susceptible weevils.

In view of the knowledge acquired, the obvious course was to define as exactly as possible the range of action by means of wide-scale testing in order to render the evidently existent polytoxicity useful to crop protection practices. So far almost one hundred species of major economic importance have already been identified as being susceptible to the active substance. Practically

all orders of Hexapoda include important species which respond to the insecticide. An indication of the range of action is given in the following list which is by no means claimed to be complete; in fact this does not represent the final level. It is a known fact that new uses are constantly discovered in the course of time for all active substances. This is perfectly clear when one considers that the number of noxious insect and mite species may be estimated at approximately 5000.

List of pests identified as susceptible to GUSATHION

Acontia dacia
Aedes aegypti
Alabama argillacea
Anastrepha ludens
Anomus teana
Ancylis comptana fragariae
Anopheles quadrimaculatus
Anthonomus grandis
Anthonomus pomorum
Aonidiella aurantii
Aonidiella citrina
Aphis fabae
Aphis gossypii
Aphis pomi
Aphrophora sp.
Archips argyrospila
Argyroploce variegana
Argyrotaenia velutinana
Aspidiotus britannicus
Aspidiotus hederae

Bemisia tabaci
Bucculatrix gossypii

Calandra granaria
Capua reticulana
Carpocapsa pomonella
Cemiostoma scitella
Ceutorrhynchus assimilis
Cheimatobia brumata
Chrysomphalus dictyospermi
Cirphis unipuncta
Coccus hesperidum
Coccus pseudomagnoliarum
Conopia exitiosa
Conotrachelus nenuphar
Culex quinquemaculatus

Diaspis pentagona
Dysdercus ruficollis
Dysdercus suturellus

Earias insulana
Empoasca sp.
Epilachna varivestis
Eriocampoides limacina
Estigmene acrea
Euproctis chrysorrhoea
Evergestis rimosalis

Frankliniella sp.

Gryllus domesticus

Heliothrips haemorrhoidalis
Hellula undalis
Hemerocampa vetusta
Hyponomeuta malinella

Icerya purchasi

Laphygma exigua
Laphygma frugiperda
Lecanium corni
Lecanium nigrofasciatum
Leptinotarsa decemlineata
Locusta migratorius migratorioides
Loxostege similalis
Lymantria dispar

Macrosiphum solanifolii
Malacosoma neustria
Meligethes aeneus
Metatetranychus ulmi
(Paratetranychus pilosus)
Musca domestica
Myzus chelidonii
Myzus persicae

Paratetranychus citri
Pectinophora gossypiella
Pieris brassicae

Pieris rapae
Platynota sp.
Plutella maculipennis
Polychrosis botrana
Prodenia litura
Prodenia ornithogalli
Psallus seriatus
Pseudococcus citri
Psylla pyricola

Rhagoletis pomonella
Rhopalosiphoninus latysiphon
Rhopalosiphum insertum
Rhyacionia buoliana
Sacadodes pyralis
Saissetia aleae
Sappaphis plantaginea
Sitophilus oryza
Synanthedon pictipes

Terioaphis ononidis
Tetranychus althaeae (T. bimaculatus)
Tetranychus atlanticus
Tetranychus tumidus
Tmetocera ocellana
Tortrix viridana
Trichoplusia ni

List of pests known to be relatively resistant

Agrotis segetum

Brachytydeus caudatus

Heliothis armigera
Hellula undalis
Mamestra oleracea

Tarsonemus fragariae
Tarsonemus pallidus

The finding that scale insects are very highly susceptible is of particular significance. Extensive studies conducted in South Africa and the U. S. A. have shown that *Coccus hesperidum*, normally a species which is extremely difficult to control, is very susceptible to GUSATHION. Particularly this species has in recent years become a pest of increasing importance in intensive citrus growing areas, and because of its resistance has constituted a serious problem to growers. GUSATHION has meanwhile been tested against a number of scale insect species, and applied at a concentration of 0·02—0·04 % active substance this product has proved to be effective against the following species:

Aonidiella aurantii
Aonidiella citrina
Aspidiotus britannicus
Aspidiotus hederae

Chrysomphalus dictyospermi
Coccus hesperidum
Coccus pseudomagnoliarum
Diaspis pentagona

Lecanium corni

Pseudococcus citri

Saissetia oleae

6. Compatibility with plants

During the wide-scale testing of GUSATHION, it was found that this product is extremely compatible with plants. No reports have been received to date of injuries being inflicted on a large number of fruit varieties, citrus, cotton, alfalfa, hops, tobacco, cereals, brassicas, beans, roses.

7. Important uses

From available data on the range of action and plant compatibility, the following crops stand out as provisionally important fields of application for GUSATHION:

a) Cotton: Here, GUSATHION is already being used on a wide scale in the major growing regions.

b) Citrus: Due to its effect against scale insects, and its good acaricidal and aphicidal action, the product shows every promise of becoming an all-round insecticide and acaricide for the protection of this crop.

c) Fruits: The wide range of efficacy against such major pests as codling moth, caterpillar species, spider mites and aphids — consideration must also be given to the good effect given against resistant mites in Italian fruit farming — arouses very great interest especially for the so-called regions of resistance. In the fruit growing regions of South Tyrol and in the Ferrara area, tests were conducted extending over a period of two years; it was established that at an active substance concentration of 0·04 % GUSATHION gives a 100 % initial effect and a residual effect lasting four to six days against resistant fruit tree spider mites. Two spray applications carried out at the right time led to the extermination of a complete population. Moreover, our own tests show that GUSATHION is effective against the most varied of pest species occurring in the course of the growing season, and can therefore be included as an insecticide in normal spraying schedules.

In view of the product's range of efficacy, many more uses will be found for GUSATHION.

IV. Residues

The long residual effect of GUSATHION naturally raises the question of residues in harvest crops.

Exhaustive studies have been conducted at the Citrus Experiment Station, Riverside, U. S. A., on cotton plants and especially on cottonseed, with the object of clarifying this question. The special interest displayed in the new compound by American cotton growers made it a matter of extreme urgency to deal with the problem of residues because in this branch of agriculture it is often necessary to carry out controls shortly before the harvest, added to which the oil yielded from the seeds is used for human food and the press cakes utilized as cattle fodder.

The results of the investigations conducted at Riverside are given in a detailed publication (2).

Meanwhile, tolerances for GUSATHION residues have been stipulated in the Federal Register of August 16, 1957 (P. 6589, Title 21 Food and Drugs, § 120, 154). They are:

2 ppm for apples, apricots, nectarines, peaches, pears, quinces;

0·5 ppm in or on cottonseed.

Generally speaking, the situation regarding the residue problem may, therefore, be regarded as most favourable.

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On the question of storing treated and wet grain seed

by A. Becker,

Crop Protection Division of the Chamber of Agriculture (Rhineland), Bonn

Seed treatment is one of the oldest and most widely spread crop protection practices, and also one of the most economical. In the past numerous products and methods have been recommended for treating seed with varying success. Up to a few years ago, milk of lime, vinegar water and liquid manure were used on small farms to treat seed but one treatment with dry dressings containing mercury has generally become an established practice. The use of wet mercury

dressings attaches relatively little importance because of difficulties involved with dosaging and the back-drying of wet, treated seed. Consequently, the most widely used dressings are the dry mercury products to which repellents are added in order to prevent attacks by crows, or insecticides containing lindane, dieldrin or aldrin to give control of wireworms and white grubs.

When seed has been treated, what is the position regarding storage? This question is often asked, and its answer is of great interest to farmers. But we find it necessary to subdivide this question because allowance has to be given to several factors, and therefore it is not possible to provide a general answer.

The first task is to establish whether normal seed can be treated in storage with dry mercury dressings.

A more difficult proposition is encountered when the product is not a pure dressing but is a combined dressing and insecticide. Is storage treatment possible in this case?

Following the introduction of the combined harvester and the change-over to a new threshing method, and also as a result of the large amount of rainfall during the Summer months in the last few years, there is a high percentage of seed with a water content of more than 15—16 %. In many places however, great difficulty is still being experienced with the back-drying of such seed so that often it is sown with a water content of more than 16 %. Can such seed be treated, and also stored for a certain period where local conditions do not permit immediate sowing?

Another point of interest concerning the storage of treated seed is whether the addition of a small amount of water to bind the dust during the treatment procedure has any influence on the germinating capacity and growth vigour of the seed. This problem has become an important one at seed treatment centres because very many operators refuse to be constantly exposed to contact with the dust of the mercury dressing, which settles on storage buildings in a wide radius of the seed treatment centre. In order to remedy this condition, my co-worker, van de Sandt, developed for operators at Poppelsdorf an apparatus by means of which 0·5 % water is fed into the dressing drum to bind the dust during the last part of the treatment process (4). Studies conducted by Prof. Klimmer (report submitted to the Crop Protection Office, Bonn, on December 7, 1954) of the Pharmacological Institute at Bonn University, confirmed the success of binding the dust in measurements carried out on the sucking appliance at a seed treatment centre; according to the results obtained the automatic addition of small quantities of water to the seed being treated, largely prevents contamination of the surrounding air by dressing dust.

The pertinent literature contains little information on these questions, that is with precise numerical data. The question concerning the storability of dry, dressed seed with a normal water content of 15 %, is generally answered in the affirmative. It is only for combined seed dressings and insecticides that the experts advise against carrying out storage treatment (5). Exhaustive checks will still have to be carried out in respect of this latter problem. Hinke (1) carried out trial treatments with combined dressings applied to Spring rye and Spring wheat with a water content of 15·8 %; after this seed had been treated with mercury-lindane products and stored for periods of 3, 6, 10, 17 and 24 days, Hinke found that the germinating capacity was immediately reduced appreciably and even more so with prolonged storage. In fact the germinating capa-

city of Spring wheat had dropped to 0 % after 24 days. On the other hand, the germinating capacity was hardly affected in seed which was treated with mercury-aldrin and mercury-dieldrin products, and had a normal moisture content. The values obtained were even more unfavourable for seed with a water content of 18·7 and 20 %, respectively. With respect to the tests carried out by Hinke, it should be mentioned that in addition to the seed which germinated normally, a considerable percentage germinated abnormally in that the coleophiles were hypertrophic. This condition of hypertrophy is caused by overdosed treatment and especially following application of mercury-lindane products, which was also established in the tests carried out by the author

Fig. 1: The plants in box II bear symptoms of marked hypertrophy caused by excessive applications of mercury-lindane. Photo by Crop Protection Office Bonn (E. Hüsken)

(Fig. 1). It should be mentioned that symptoms of hypertrophy are observed mainly in tests carried out on filter paper and in sand seed beds whereas in normal growing conditions they are hardly apparent.

E. Reinmuth and M. Hopf (3) reported on the storage treatment of rye, barley and oats with varying contents of water based on studies conducted by the Institute for Phytopathology and Crop Protection at the University of Rostock. The seed used in these tests was of poor quality, and the rye was severely infected by fusarium. After being treated, the different samples — 500 g and 250 g, respectively, in each batch — were stored in closed glass vessels in an unheated room. Details of these tests are given in Tables 1 and 2.

Table 1: Average water content of rye and barley samples during testing period

	at start of test %	after 3 weeks %	after 5 weeks %	after 8 weeks %	Remarks
Rye					
stage 1					
treated			21·0	21·1	
untreated	20·6	20·2	21·9	22·5	
stage 2					
treated			18·9	16·5	
untreated	18·1	18·9	18·8	16·8	
stage 3					
treated			16·2	14·7	
untreated	15·6	16·4	16·9	14·7	
Barley					
	20·8	19·9	19·4	18·0	only very slight differences
untreated	18·3	17·1	17·0	16·8	in water content between
	15·8	14·7	14·0	12·8	treated and untreated seed

The untreated batch with a water content of 20·6 % was covered with a layer of green mould and had a marked musty smell after only 10 days of storage, despite the low room temperature. At this time the treated samples still had a healthy appearance. The authors arrived at the following conclusions drawn from the results of their tests:

"... In summarizing, it can be said that storage treatment of seed is not only harmless to the stored seed when the dressing is applied at standard dosages but also that seed which is not completely healthy — in our case, rye infected by fusarium and moulds — should be treated as promptly as possible, if it can still be used at all for sowing. This applies particularly to seed with a high water content, which anyway has a tendency to become infected by mould. Persistent protection against fungal infection is, however, not afforded by dry dressings when the seed has a high water content but just the same dry-dressed seed is still far healthier than untreated seed four weeks after the application, also when the water content is fairly high."

Further tests were conducted by H. A. Kirchner (2), Rostock branch of the Central Biological Institute, Berlin-Kleinmanchnow, with 300 kilos of rye. The seed, split up into batches which were each given a different treatment, was stored in six open paper sacks each containing 50 kilos. The water content varied between 14·5 and 20·1 %. Procedure at 20·1 % water content: batch A — untreated, not moved; B— treated, not moved; C — untreated, turned over

Table 2: Germinating capacity of treated and untreated rye (R) and barley (G) at different grades of water content during testing period of 8 weeks.

Moisture	after 1 week		after 2 weeks		after 4 weeks		after 8 weeks	
	R	G	R	G	R	G	R	G
			I. Dry dressing A					
grade 1	83·5	96·0	97·5	98·1	98·9	98·3	90·2	96·1
grade 2	66·0	96·5	98·0	97·5	86·0	96·3	72·5	96·4
grade 3	68·0	97·6	83·8	99·0	53·2	95·8	42·5	94·3
			II. CERESAN® Dry Seed Dressing					
grade 1	—	—	—	—	—	—	—	—
grade 2	76·0	92·8	95·1	94·7	90·3	96·5	77·5	95·0
grade 3	70·0	94·7	95·0	97·8	67·2	94·3	51·5	91·1
			III. Dry dressing B					
grade 1	83·5	93·8	99·0	96·7	97·3	96·2	92·2	96·3
grade 2	81·0	93·5	97·1	95·5	78·8	93·7	69·8	92·5
grade 3	77·0	94·9	88·0	96·8	56·4	95·0	40·3	85·8
			IV. untreated					
grade 1	96·0	93·3	97·0	95·5	93·6	95·0	84·5	97·7
grade 2	94·0	96·0	96·0	96·0	72·3	92·0	49·3	89·0
grade 3	65·0	93·3	68·8	94·0	49·3	91·7	39·0	89·3

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with a shovel twice weekly; D — treated, turned over with a shovel twice weekly; at 14·5 %: E — treated, not moved; F — untreated, not moved. At certain intervals, a check was made on the percentage of mouldy grains, and the mite infestation was registered at the end of the testing period. The following values were obtained:

Table 3:

Batch	Percentage of mouldy seed on 2. 12.	21. 1.	21. 2.	21. 3.	Mite infestation on 21. 3. 1955
A	21·0	41·0	38·0	26·0	severe infestation
B	25·5	21·0	25·5	14·5	no infestation
C	0	0·5	4·0	3·0	no infestation
D	0	0	2·0	1·5	no infestation
E	0	0	0	0	no infestation
F	7·0	19·0	18·0	12·0	slight infestation

At the close of the tests, the germinating capacity and growth vigour were equally poor for both treated and untreated seed, that is when the seed was not moved during storage. A storage treatment of rye with a normal water content proved to be completely harmless to the seed even when stored for a period of 18 weeks.

A series of tests was carried out by the author in 1954/1956 to examine the growth vigour and germinating capacity of differently treated seed in dependence on storage. Normal dry rye, wheat, barley and oat seed was treated on November 25, 1954. The treated seed was examined for growth vigour by means of the Hiltner method on November 25, 1954; the tests for germinating capacity were carried out on November 30, 1954, in Petri dishes using absorbent paper as the seed bed. The germinating capacity and vegetative vigour of the rye used in the tests were not satisfactory from the ouset. The differently treated seed was stored in paper sacks in a dry and well-aired loft at the Crop Protection Office, and left there until the next checks were made, approximately 6 months and one year later. The results of these checks and treatments are given in Table 4. It is evident from the figures recorded that the germinating capacity and growth vigour of dry seed were not unfavourably influenced by treatment and long storage, in comparison with untreated seed. Treatment with mercury-lindane products did, however, reduce the growth vigour of wheat somewhat. The values registered for treatment of wheat with mercury-lindane combinations nevertheless do not indicate that a storage treatment with these products is not possible. The growth vigour of barley, oats and rye was not adversely affected following combined treatment so that grain seed treated even with mercury-lindane preparations can be used for sowing after one year of storage, although a reduction in the effect of insecticidal active ingredients must be expected in such cases. It should also be mentioned that in tests of combined seed dressings, it is advisable to check primarily for growth vigour because any abnormal germination initially observed in the sand seed bed or on filter paper need not necessarily have unfavourable influence on the growth vigour and later development of the seed.

A second series of tests was arranged with the object of examining the influence of treatment on the germinating capacity and growth vigour of moist rye when stored for a lengthy period. At the start of the test, the rye (Petkuser Normalstroh variety, 1956 harvest) had an average water content of 19·6 to 19·8 %, and already smelt musty. The germinating capacity amounted to only 60 %. Consequently the batch was no longer suitable as seed. The rye was treated on October 8, 1956 at Lommersum (district of Euskirchen), using a hand-operated dressing drum (50 kilo capacity), according to the following test plan:

1. CERESAN-gamma	200 g/100 kilos
2. Untreated	
3. Commercial seed dressing A *	200 g/100 kilos
4. CERESAN + MORKIT®	each 200 g/100 kilos
5. Commercial seed dressing B	200 g/100 kilos

* The Crop Protection Office at Bonn will supply requested information on the products used.

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6. CERESAN — 200 g/100 kilos
7. Not dressed, but treated with MORKIT — 200 g/100 kilos
8. CERESAN-MORKIT new — 200 g/100 kilos
9. CERESAN + water — 200 g/100 kilos + 1 l water
10. CERESAN + MORKIT + water — each 200 g/100 kilos + 1 l water
11. Commercial seed dressing B + water — 200 g/100 kilos + 1 l water
12. Commercial seed dressing A + water — 200 g/100 kilos + 1 l water

Before the treatment was carried out, the entire batch of rye seed was heaped up and thoroughly mixed in the store-room by turning it over with a shovel. 50 kilos of rye were used in each test.

Table 4: Seed treatment test 1954/56: Examination of growth vigour and germinating capacity of treated seed in dependence on storage.

		Germinating capacity		Growth vigour		
		30. 11. 1954	16. 1. 1956	26. 11. 1954	21. 6. 1955	13. 1. 1956
Rye						
Untreated		81 %	76 %	84 %	66 %	64 %
CERESAN	200 g/100 kilos	87 %	76 %	85 %	68 %	66 %
Commercial seed dressing A *	200 g/100 kilos	85 %	80 %	74 %	84 %	62 %
Commercial seed dressing B	200 g/100 kilos	79 %	71 %	76 %	76 %	64 %
Commercial seed dressing C	200 g/100 kilos	76 %	69 %	68 %	66 %	66 %
Wheat						
Untreated		99 %	96 %	95 %	86 %	90 %
CERESAN	200 g/100 kilos	99 %	98 %	95 %	87 %	90 %
Commercial seed dressing A *	200 g/100 kilos	99 %	96 %	99 %	91 %	84 %
Commercial seed dressing B	200 g/100 kilos	100 %	97 %	98 %	95 %	96 %
Commercial seed dressing C	200 g/100 kilos	97 %	98 %	99 %	76 %	78 %
Barley						
Untreated		96 %	96 %	94 %	86 %	88 %
CERESAN	200 g/100 kilos	98 %	92 %	90 %	94 %	95 %
Commercial seed dressing A *	200 g/100 kilos	98 %	96 %	88 %	90 %	93 %
Commercial seed dressing B	200 g/100 kilos	99 %	92 %	94 %	89 %	92 %
Commercial seed dressing C	200 g/100 kilos	98 %	95 %	92 %	78 %	90 %
Oats						
Untreated		93 %	90 %	95 %	86 %	80 %
CERESAN	200 g/100 kilos	97 %	93 %	95 %	87 %	88 %
Commercial seed dressing A *	200 g/100 kilos	95 %	90 %	96 %	91 %	88 %
Commercial seed dressing B	200 g/100 kilos	96 %	89 %	98 %	94 %	89 %
Commercial seed dressing C	200 g/100 kilos	95 %	93 %	87 %	74 %	87 %

* The Crop Protection Office at Bonn will supply requested information on the products used.

In order to carry out the test on a wider basis, several approved seed dressings were used; the test also included a combined mercury-lindane preparation. The manager of a seed dressing organization had observed that the addition of MORKIT to wet seed has a favourable effect, and in view of this MORKIT, a repellent, was also included in the test, applied on its own and in combination with a mercury seed dressing. 1 % of water was added to several of the treated batches to bind the seed dressing dust.

After being treated the rye was placed in sacks, labelled, tied up and stored. At the time the test was carried out, the temperatures in the store-room were very low, and almost corresponded with the temperature outdoors.

Table 5:

Treatment	Germinating capacity in %					Growth vigour in %				
	9. 10. 1956	23. 10. 1956	5. 11. 1956	20. 11. 1956	6. 2. 1957	9. 10. 1956	23. 10. 1956	5. 11. 1956	20. 11. 1956	5. 12. 1956
1	54	66·5	52·5	60	51	57·5	55·5	59	52	56·5
2	59	56·5	54	54·5	—	50	49·5	45·5	41	47
3	60·5	56·5	59	45·5	44	61·5	45	50·5	45·5	47
4	51·5	59	53	58·5	51	65	56	55	57	59
5	46·5	59	49·5	49·5	43·5	60·5	53·5	55·5	42	50
6	51·5	48·5	54	61·5	46	60	58	48	54	58
7	52·5	54·5	57	58·5	55	60·5	55·5	59·5	38	43·5
8	49	53·5	61	54·5	55	67	48·5	45	55·5	56
9	55	55	60·5	49	38·5	63	55·5	54	47·5	50·5
10	48·5	59	58	55·5	47·5	64	51	53	50·5	53·5
11	48	50·5	53·5	47	45·5	57	52·5	48·5	40	40
12	51·5	53	56	53	42·5	49·5	57	62·5	60	57

The first sampling to check on germinating capacity and growth vigour was carried out immediately after the treatment, and then at intervals of 14 days. The tests for establishing the degree of germinating capacity and growth vigour were started on the following dates:

1. 9. 10. 1956
2. 23. 10. 1956
3. 5. 11. 1956
4. 20. 11. 1956
5. 5. 12. 1956 (only growth vigour)
6. 6. 2. 1957 (only germinating capacity)

The test for germinating capacity was carried out with 2 batches of 100 grains which were spread out on moist absorbent paper in Petri dishes, while the tests for growth vigour were carried out according to the method of Hiltner in 4 zinc boxes each containing 50 grains. The average figures recorded for germinating capacity and growth vigour are given in Table 5, and are expressed in percentages.

All the values recorded were very low and there was a high degree of deviation; this was to be expected considering the poor state of the rye. There was no sign of the different seed dressings and insecticides having any influence on the germinating capacity and growth vigour of the unusually moist seed, even when stored in sacks for several weeks in a well-aired room. Even the slight addition of 1 % of water to bind the seed dressing dust had no adverse effect under the unu-

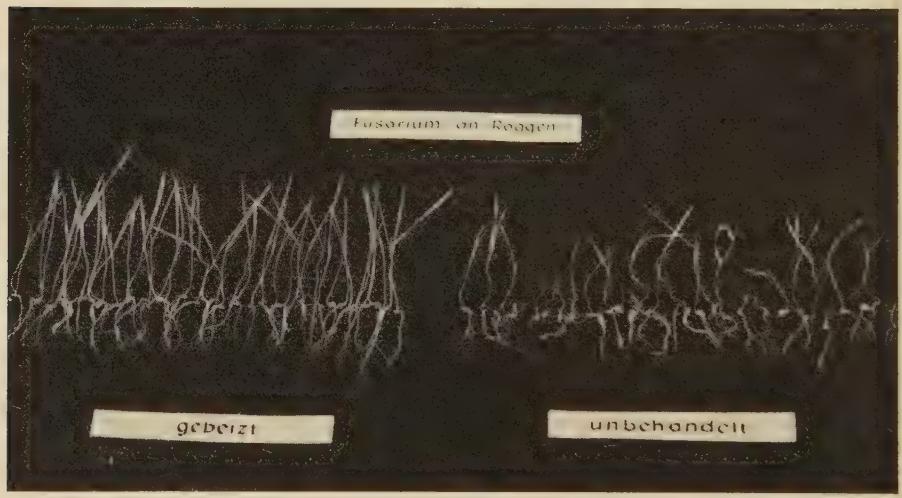

Fig. 2: Rye seed, treated and untreated
Photo by courtesy of the Crop Protection Office, Bonn (E. Hüsken)

Fusarium an Roggen = Fusarium on rye; gebeizt = treated; unbehandelt = untreated

sually unfavourable conditions. Despite the fact that the test results obtained were most satisfactory, it must always be our aim only to use and treat seed which has a water content of less than 16 %.

During the storage period, the moisture content of the differently treated batches of rye was determined at certain intervals, partly by means of an Aqua-Part apparatus, and partly with the help of a drying chamber. The following values were obtained:

During the testing period, no appreciable differences in water content were established for treated and stored rye. By adding 1 % of water during the treatment operation, the moisture content of the rye was increased by an average of 0·5 %.

In order to register the influence exerted by the different treatments on the emergence and growth vigour of rye, a field test was carried out on November 19, 1956. The seed was sown along the same lines adopted in the seed dressing tests, on plots 3 sq. metres in area. 25 gr. of seed was sown per plot, and dosed with the aid of marked test tubes. The tests were carried out with 3 replications. The test field was located at Buschdorf near Bonn, and the soil

Table 6: Moisture content of treated rye during storage.

Treatment	22. 10. 1956		6. 11. 1956		26. 11. 1956
	A * %	T ** %	A %	T %	T %
1	18·5	18·5	17·5	17·5	18·5
2	18·5	18·5	17·8	17·7	18·5
3	18·6	18·5	18·0	17·8	18·3
4	18·5	19·0	18·1	17·5	18·0
5	18·6	18·5	17·9	18·0	18·3
6	18·4	18·5	17·9	17·5	19·3
7	18·5	19·0	17·9	17·0	18·5
8	18·9	19·0	18·1	18·0	18·3
9	19·0	19·0	18·6	18·3	18·7
10	19·0	19·0	18·6	18·5	18·3
11	19·0	19·0	18·3	18·0	18·7
12	19·0	19·0	18·5	18·6	18·7

* determined by means of Aqua-Part apparatus.
** determined by means of a drying chamber.

was loamy sand. Due to the early period of cold weather at the end of November, the emergence of the grain was delayed considerably. At the beginning no appreciable differences in crop density were noted. Towards the end of the Winter season, however, striking differences in crop density were observed. In order to record these differences numerically, a count was taken of the plants on March 25, 1957. The results obtained are given in Table 7.

They clearly show what danger arises when rye is not treated. In the untreated plots, there were not half as many plants as in those which were dressed. Plot 7 (treated only with MORKIT) had a particularly good crop. It should be checked whether the active ingredient of MORKIT possesses certain fungicidal properties which are stated to have been observed especially

on moist grain. Plot 1 has a very good crop although here moist grain was dressed with mercury-lindane products and stored for 6 weeks.

The test clearly indicates the necessity of dressing rye to give it protection against fusarium infection. Incidence of this disease was very severe in 1956, which is also indicated in Fig. 2. The differences would have been even greater if there had been a lot of snow during the Winter of 1956/57. The mild conditions during winter with little snow prevented complete nipping by frost not only on the untreated test plots but also on extensive field crops of rye because unfortunately treatment of rye generally still leaves much to be desired. During

Table 7: Crop density per plot

Treatment	Test series I No. of plants	II No. of plants	III No. of plants	average No. of plants
1	280	285	305	290
2 (untreated)	145	140	110	131·6
3	235	250	275	253·3
4	265	260	265	263·3
5	380	315	270	321·6
6	365	320	290	325
7 (MORKIT)	195	340	225	253·3
8	260	240	305	268·3
9	185	285	280	250
10	325	310	300	311·6
11	240	245	255	246·6
12	215	325	315	285

an enquiry carried out in a progressive area, 50 % of the students at an agricultural college admitted that untreated rye is sown at the farms of their parents and tutors.

In the very favourable Spring weather conditions, tillering was very pronounced even in plots of untreated rye so that as time passed the differences which at first were most perceptible lessened appreciably. For technical reasons harvesting and numerical weight determinations had to be omitted.

It must however be emphasized that not only rye but all grain may be infected by fusarium, especially wheat. This was clearly demonstrated in seed treatment tests carried out with wheat in 1956/57. A count of the plants per sq. metre produced the following results in seed treatment tests at the Agricultural College, Löwenich:

Test I	untreated: a 118	b 148 plants per sq. metre
	treated: a 382	b 413 plants per sq. metre
Test II	untreated: a 102	b 105 plants per sq. metre
	treated: a 348	b 361 plants per sq. metre

Fig. 3: Inhibition of germination and swelling due to the use of large overdosages
Top: Normally treated (200 g/100 kilos)
Bottom: Use of large overdosage (800 g/100 kilos)
Photo by courtesy of Crop Protection Office, Bonn (E. Hüsken)

It is absolutely essential when treating seed only to use the prescribed dosage. Checks carried out by crop protection authorities at seed treatment centres showed however that there were large differences in the dosages used every year. It was even found in certain cases that overdosages have been applied which were four times larger than the recommended dosage; naturally this led to severe emergence injuries (Fig. 3). Such injuries often result in claims being made for compensation, which is not a very desirable practice. In Spring 1957 a seed treatment centre which up to that time had not been affiliated to the local crop protection office, had to pay compensation amounting to several thousand DM to cover severe emergence injuries caused by overdosaging.

If in addition to the application of an overdosage the grain has a high moisture content, the damage will be even greater. Several dressings also have

a more aggressive effect, for example those with a high vapour tension (strong odour), whereas others with a low vapour tension (weak odour) have a mild effect.

Seed should not be sown too deep, and soil which is too wet should not be used for planting out.

New problems are constantly encountered in the treatment of seed, and it is essential that very close attention is given to these because after all about 60 % of our fields are set with cereals. Interest should be given primarily to investigations on the application of combined dressings and insecticides because here opinions on the possibility of a long storage especially when the grain has a high moisture content still differ most considerably.

The following conclusions may be drawn in respect of the author's tests:

1. Dressed grain can be stored for a lengthy period without affecting the germinating capacity and growth vigour.
2. Grain which has a high moisture content should be dried before it is stored. Dressing should be carried out at all events before the seed is sown. It is most advisable to sow the seed immediately after it has been treated although when storage conditions are cool and offer plenty of air seed can be treated prior to storage because the danger of poor emergence is greater for untreated, wet grain than for treated, wet grain.
3. The addition of a little water to bind the dust when carrying out the treatment does not affect the germinating capacity and growth vigour. This has been proved by tests carried out under the most unfavourable conditions.

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Studies on the question of the influence of seed treatment and water content of grain on latter's storage property

by P. E. Frohberger

In recent years, several cases have been reported to us of poor emergence of grain seed, attributed either to overdosages of products applied in the treatment of the seed thus inflicting harm, or to a high water content of the seed. We have ourselves established — and in fact we have been informed of this from other quarters — that there is a great tendency to conclude from this view that it is advisable in years of wet harvesting weather not to treat seed in order to be on the safe side. Judging from the experience we have accumulated with nonvolatile organic mercury compounds, this conclusion is not objective, and moreover is injurious to the policy of seed treatment. However, in order to have sufficient proof as to the harmlessness of an almost normal seed treatment with CERESAN,® should ever it be necessary to establish our point, we conducted an extensive series of tests with the object of furnishing answers to the following questions:

What effect does the varying water content of seed have upon the rate of germination, the germinating capacity and the development of young plants, when the seed is

A. stored in sacks or in high stacks before sowing, namely
   1. untreated,
   2. treated in the normal manner,
   3.—6. treated with varying overdosages;

B. stored in the same way untreated, but then dried and treated immediately before sowing
   1. untreated,
   2. treated in the normal manner,
   3.—6. treated with varying overdosages.

A special point to be established was whether, in addition to harm directly caused by moisture, an increase is brought about in the susceptibility of seed to dressings and possibly to overdosages.

Material and method

Seed: Winter wheat of Carstens VI high-grade variety
12·7 % water content (dried back from 16·8 %)
16·8 % natural water content
18·8 % water content (16·8 % natural + 2 % extra)
20·8 % water content (16·8 % natural + 4 % extra)
22·8 % water content (16·8 % natural + 6 % extra)
24·8 % water content (16·8 % natural + 8 % extra)
26·8 % water content (16·8 % natural + 10 % extra)
22·8 % water content (16·8 % natural + 12 % extra)

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The back-drying was carried out at room temperature and an approximate relative humidity of 40 % on filter paper laid out flat. The seed was placed in batches of 1 kilo in tightly closed powder bottles, which meant that these latter were half-filled (air space for seed to breathe). The seed was moistened in these bottles to give the water content listed above by adding the proper quantities of water, followed by frequent shaking. Seed treatment was carried out

A. 24 hours after moistening, that is when the added water had been fully and evenly absorbed by the seed;

B. after the back-drying of the seed samples stored with varying contents of moisture, immediately before sowing.

The air-tight bottles containing the seed samples were aired daily for one second with compressed air. The water content, in consequence, remained practically unchanged without natural respiration being disturbed. Treatment A prior to storage and treatment B after storage were carried out with CERESAN U. T. 11975 b applied in standard, double, treble, four-fold and five-fold dosages.

The seed was sown in elutriated river sand which due to its weak absorptive power would allow any harm caused by seed treatment to show up far more clearly than in clayey and humous arable soil. From each seed sample, 2 × 100 grains were sown in each operation; these were covered with a layer of muslin, and then a 1 centimetre layer of sand placed on top. The use of the muslin layer enabled the top layer of sand to be lifted off in the evaluation of the test, and the seeds to be checked for their state of germination. The boxes of seed were cultivated in the air-conditioned greenhouse in every consecutive sowing operation, under constant conditions of 18 ° C and approx. 80 % relative humidity. The first sowing operation was carried out before storage to determine the initial state and the direct effect of the water content of the seed and the various dosages of seed dressing. The second batch of seed was sown after 17 days' storage and the third after 47 days' storage.

In the tables 1 to 8, the following data are given for sowing operations 1 to 3:

I the percentage of emergence 7 days after the respective sowing operation to record the rate of germination;

II the percentage of emergence 14 days after the respective sowing operation to determine the germinating capacity;

III the fresh weight of the shoots, based on 100 sown wheat grains, to determine quantitatively the growth vigour;

IV the number of weakly sprouting seedlings which were not able to penetrate the 1 cm thick top layer, and which, therefore, germinated but did not emerge;

V the number of hypertrophic seedlings which as a rule occur due to damage by mercury compounds.

The non-germinated seeds are not included numerically in the tables. Their numbers can be calculated by deducting from 100 the sum total of emerged, weakly sprouting and hypertrophic seedlings.

Table 1: Winter wheat, Carstens VI high-grade variety, 12·7% water content (dried back from 16·8%)

No.	Dosage of UT 11975b in g/kg	I			II			III			IV			V		
		Average figures, based on 100 caryopses														
		emerged plants						fresh weight of shoots			non-emerged plants					
		on 7th. day			on 14th. day			on 14th. day			weakly sprouting			swollen seedlings		
		1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.
A. Pre-storage seed treatment																
1	0	86·0	67·5	64·5	89·5	85·0	84·0	8·58	6·35	5·25	1·5	6·5	3·0	0	0	0
2	2	93·0	90·5	85·5	98·5	96·5	94·0	10·51	8·66	7·84	0	1·0	4·0	0	0	0
3	4	86·5	81·5	73·5	91·5	90·5	89·0	9·48	8·42	7·88	0	2·5	0·5	0	0·5	3·5
4	6	93·0	68·0	47·5	95·0	84·5	77·5	10·71	7·61	5·92	1·5	2·5	1·5	0·5	4·5	11·5
5	8	84·5	50·0	15·0	91·5	71·0	53·0	9·32	6·17	3·38	1·0	0	5·0	1·0	14·0	22·0
6	10	89·0	0	0	95·5	2·0	0·5	9·90	0·08	0·02	0	0·5	1·0	0	37·5	14·0
B. Post-storage seed treatment, and back-drying to 12·6% (2nd. sowing) and 11·1% (3rd. sowing) water content, respectively																
1	0	—	77·0	58·0	—	88·5	86·5	—	5·44	6·27	—	4·0	6·0	—	0	0
2	2	—	93·0	88·0	—	93·5	94·5	—	8·12	8·91	—	3·0	1·5	—	0	0
3	4	—	97·5	86·5	—	100·0	95·0	—	9·25	8·87	—	0	3·5	—	0	0
4	6	—	91·5	82·5	—	95·0	92·0	—	8·27	9·93	—	1·0	1·0	—	0	1·0
5	8	—	85·0	77·0	—	93·5	95·5	—	8·34	9·41	—	1·5	3·0	—	0	0·5
6	10	—	75·0	66·0	—	88·5	91·5	—	7·42	8·42	—	1·0	3·0	—	4·5	0·5

Table 2: Winter wheat, Carstens VI high-grade variety, 16·8% natural water content

No.	Dosage of UT 11975b in g/kg	I			II			III			IV			V		
		Average figures, based on 100 caryopses														
		emerged plants						fresh weight of shoots			non-emerged plants					
		on 7th. day			on 14th. day			on 14th. day			weakly sprouting			swollen seedlings		
		1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.
A. Pre-storage seed treatment																
1	0	81·5	77·0	52·0	85·5	87·0	75·0	8·38	6·71	4·75	3·0	3·0	7·0	0	0	0·5
2	2	86·0	62·5	66·0	96·5	96·5	90·0	10·03	8·10	7·12	0·5	1·0	1·5	0	0	0·5
3	4	92·5	4·0	0·5	97·0	49·0	53·5	10·46	2·14	2·25	0	8·5	9·5	0	34·0	18·0
4	6	92·5	0	0	96·5	0	2·0	10·14	0	0·02	0	2·5	3·0	0	57·5	31·5
5	8	74·5	0	0	90·0	0	0	8·55	0	0	1·0	0	0	1·5	16·0	0
6	10	70·0	0	0	87·0	0	0	8·18	0	0	1·0	0	0	4·0	7·0	0
B. Post-storage seed treatment, and back-drying to 12·6% (2nd. sowing) and 11·1% (3rd. sowing) water content, respectively																
1	0	—	70·0	55·0	—	83·5	74·0	—	5·74	6·58	—	4·0	4·5	—	0	0
2	2	—	89·5	64·0	—	93·0	83·5	—	8·48	8·33	—	1·5	3·5	—	0	0
3	4	—	88·0	60·0	—	93·5	87·5	—	8·78	8·04	—	2·0	4·5	—	0	0
4	6	—	86·0	44·5	—	93·5	82·5	—	8·27	7·99	—	0·5	3·0	—	1·0	0
5	8	—	66·0	39·5	—	90·5	80·0	—	7·65	6·95	—	0·5	4·5	—	1·5	0·5
6	10	—	68·0	41·5	—	91·0	83·5	—	7·49	7·00	—	3·5	2·0	—	1·0	2·5

Table 3: Winter wheat, Carstens VI high-grade variety, 16·8% natural water content + 2% addition of water

No.	Dosage of UT 11975b in g/kg	I			II			III			IV			V		
		Average figures, based on 100 caryopses														
		emerged plants						fresh weight of shoots			non-emerged plants					
		on 7th. day			on 14th. day			on 14th. day			weakly sprouting			swollen seedlings		
		1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.
A. Pre-storage seed treatment																
1	0	82·5	67·5	30·0	87·5	74·5	43·0	8·68	6·44	2·99	2·0	5·5	7·0	0	0·5	0·5
2	2	79·5	74·0	25·0	92·0	92·0	61·0	9·69	8·21	4·22	2·5	2·5	2·5	0	0	0
3	4	81·0	0	0	90·0	53·0	46·5	9·64	2·61	1·96	1·5	4·0	10·0	0·5	23 5	1·0
4	6	65·5	0	0	87·5	1·5	0·5	8·77	0·02	0·02	2·5	4·0	5·0	0·5	49·5	5·0
5	8	68·0	0	0	91·0	0	0	9·10	0	0	0	0·5	0	1·0	11·0	0
6	10	64·0	0	0	81·5	0	0	7·52	0	0	2·0	0	0	4·5	2·0	0
B. Post-storage seed treatment, and back-drying to 12·6% (2nd. sowing) and 11·1% (3rd. sowing) water content, respectively																
1	0	—	57·5	35·0	—	72·5	53·0	—	5·26	4·24	—	3·0	5·5	—	0	0·5
2	2	—	78·0	40·0	—	84·0	53·5	—	7·49	5.74	—	0·5	0·5	—	0	0
3	4	—	72·0	41·5	—	88·0	56·5	—	7·58	5·57	—	1·0	3·0	—	0	0
4	6	—	74·0	32·5	—	83·5	59·5	—	7·55	5·94	—	1·0	3·5	—	0	0
5	8	—	62·5	34·5	—	78·0	51·5	—	6·55	5·01	—	0·5	3·0	—	3·5	0
6	10	—	52·0	12·5	—	76·0	53·0	—	5·80	3·98	—	2·0	3·5	—	3·0	1·5

Table 4: Winter wheat, Carstens VI high-grade variety, 16·8% natural water content + 4% addition of water

No.	Dosage of UT 11975b in g/kg	I			II			III			IV			V		
		Average figures, based on 100 caryopses														
		emerged plants						fresh weight of shoots			non-emerged plants					
		on 7th. day			on 14th. day			on 14th. day			weakly sprouting			swollen seedlings		
		1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.
A. Pre-storage seed treatment																
1	0	68·5	57·5	45·5	78·5	67·5	51·5	7·51	5·28	3·96	3·5	2·0	2·5	1·0	0	0
2	2	83·0	66·5	36·0	88·5	84·0	54·0	9·70	6·87	3·86	1·0	1·5	1·0	0	0	0
3	4	85·5	10·5	16·0	92·0	62·5	51·5	9·99	3·48	2·55	1·5	5·0	6·0	0	10·5	0
4	6	72·0	0	0	86·5	14·0	4·0	8·75	0·16	0·11	0·5	8·0	0·5	1·5	38·0	0
5	8	52·5	0	0	85·0	0	0	7·73	0	0	2·5	1·5	0	0·5	30·0	0
6	10	36·5	0	0	70·5	0	0	5·84	0	0	3·0	0	0	8·0	9·5	0
B. Post-storage seed treatment, and back-drying to 12·6% (2nd. sowing) and 11·1% (3rd. sowing) water content, respectively																
1	0	—	51·5	37·0	—	62·0	49·0	—	4·24	4·43	—	6·0	4·5	—	0	0
2	2	—	64·5	49·5	—	72·0	60·5	—	6·35	5·98	—	2·5	0·5	—	0	0
3	4	—	67·5	41·0	—	71·0	55·5	—	6·76	5·62	—	2·5	0·5	—	0	0
4	6	—	72·0	32·0	—	78·5	45·5	—	7·26	5·05	—	2·5	1·0	—	0	0
5	8	—	52·5	39·0	—	67·0	45·5	—	5·79	5·11	—	0·5	1·0	—	0	0
6	10	—	41·0	27·0	—	68·0	52·0	—	5·35	5·63	—	1·5	1·5	—	1·0	2·0

Table 5: Winter wheat, Carstens VI high-grade variety, 16·8% natural water content + 6% addition of water

No.	Dosage of UT 11975b in g/kg	I			II			III			IV			V		
		Average figures, based on 100 caryopses														
		emerged plants						fresh weight of shoots			non-emerged plants					
		on 7th. day			on 14th. day			on 14th. day			weakly sprouting			swollen seedlings		
		1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.
A. Pre-storage seed treatment																
1	0	70·5	58·0	48·0	76·5	64·0	54·5	7·77	5·28	4·29	2·0	2·5	2·5	0	0	0
2	2	91·5	64·0	35·5	94·0	79·5	49·5	10·87	5·93	3·38	0·5	2·0	0	0	0	0
3	4	79·0	10·0	7·0	90·0	60·5	47·0	9·40	2·96	2·25	0·5	5·0	1·5	0	12·0	0
4	6	74 0	0	0	94·0	13·0	18·5	9·68	0·24	0·35	0	7·0	0	0	40·5	0·5
5	8	72·5	0	0	88·0	1·0	0	9·25	0·02	0	0	0·5	0	3·0	37·5	1·0
6	10	53·0	0	0	78·0	0	0	7·29	0	0	1·0	1·0	0	11·0	7·5	0
B. Post-storage seed treatment, and back-drying to 12·6% (2nd. sowing) and 11·1% (3rd. sowing) water content, respectively																
1	0	—	50·5	35·0	—	63·0	46·0	—	4·60	4·24	—	5·5	1·5		0	0
2	2	—	66·5	39·5	—	71·5	57·5	—	6·54	5·67	—	0	0		0	0
3	4	—	69·5	21·5	—	75·5	51·5		6·93	4·28	—	2·0	4·5		0	0
4	6	—	60·5	14·0	—	69·0	44·0	—	6·23	4·08	—	1·5	1·0	—	0	0
5	8	—	56·5	7·5		71·0	50·0		6·31	5·28	—	2·5	0·5	—	0	0
6	10	—	46·0	1·0	—	69·0	49·0		5·73	4·73	—	1·0	0·5		1·0	0·5

Table 6: Winter wheat, Carstens VI high-grade variety, 16·8% natural water content + 8% addition of water

No.	Dosage of UT 11975b in g/kg	I			II			III			IV			V		
		Average figures, based on 100 caryopses														
		emerged plants						fresh weight of shoots			non-emerged plants					
		on 7th. day			on 14th. day			on 14th. day			weakly sprouting			swollen seedlings		
		1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.
A. Pre-storage seed treatment																
1	0	69·5	43·5	1·5	79·0	53·0	26·5	7·68	4·17	1·48	1·5	3·0	1·0	0	0	0
2	2	88·0	58·0	1·0	91·0	77·5	30·5	10·18	5·95	1·48	1·0	2·0	0	0	0	0
3	4	84·5	9·0	1·5	87·5	57·0	13·0	10·23	2·65	0·60	2·0	8·0	0·5	0	5·5	0
4	6	72·5	0	0	90·0	10·5	3·0	9·27	0·18	0·04	0·5	16·0	0·5	1·5	34·0	1·0
5	8	64·5	0	0	81·5	0·5	0	8·54	0	0	1·5	1·5	0	3·0	26·0	0
6	10	34·0	0	0	66·0	0	0	5·23	0	0	1·0	0	0	9·0	5·0	0
B. Post-storage seed treatment, and back-drying to 12·6% (2nd. sowing) and 11·1% (3rd. sowing) water content, respectively																
1	0	—	40·5	0	—	58·0	5·0	—	3·73	0·18	—	4·5	0	—	0	0
2	2	—	49·0	0	—	72·5	12·0	—	5·60	0·56	—	1·0	1·5	—	0	0
3	4	—	30·5	0	—	68·5	10·0	—	5·33	0·40	—	1·0	6·0	—	0	0
4	6	—	22·0	0	—	70·0	9·0	—	5·45	0·32	—	0·5	6·0	—	0	1·5
5	8	—	11·5	0	—	68·0	8·5	—	5·10	0·38	—	0·5	3·5	—	1·0	1·5
6	10	—	8·5	0	—	70·0	8·5	—	4·67	0·28	—	3·5	5·0	—	1·0	3·0

Table 7: Winter wheat, Carstens VI high-grade variety, 16·8% natural water content + 10% addition of water

No.	Dosage of UT 11985b in g/kg	I			II			III			IV			V		
		Average figures, based on 100 caryopses														
		emerged plants						fresh weight of shoots			non-emerged plants					
		on 7th. day			on 14th. day			on 14th. day			weakly sprouting			swollen seedlings		
		1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.
A. Pre-storage seed treatment																
1	0	74·5	17·5	0	81·0	41·5	0	8·07	2·50	0	2·5	10·0	0	0	0	0
2	2	85·5	35·5	0	93·5	76·0	0	9·79	6·02	0	1·0	4·5	0	0	0	0
3	4	78·0	2·0	0	88·0	50·5	0	9·74	2·26	0	1·0	6·0	0	1·5	2·5	0
4	6	47·5	0	0	76·5	4·5	0	6·79	0·06	0	2·0	3·0	0	0·5	12·0	0
5	8	52·0	0	0	80·5	0	0	7·73	0	0	1·5	0	0	4·0	8·0	0
6	10	45·5	0	0	81·0	0	0	6·73	0	0	1·0	0	0	11·5	0·5	0
B. Post-storage seed treatment, and back-drying to 12·6% (2nd. sowing) and 11·1% (3rd. sowing) water content, respectively																
1	0	—	8·5	0	—	41·5	0	—	2·29	0	-	4·5	0	-	0	0
2	2	—	2·5	0	—	60·0	0	—	3·67	0	-	4·5	0		0	0
3	4	—	5·5	0	—	59·0	0	—	4·18	0	—	0	0	—	4·0	0
4	6	—	1·0	0	—	55·5	0	—	3·33	0	—	3·5	0	—	1·5	0
5	8	—	1·0	0	—	43·0	0		2·40	0	-	2·5	0	—	0·5	0
6	10	—	0	0	—	41·0	0	—	2·04	0	—	3·0	0		4·5	0

Table 8: Winter wheat, Carstens VI high-grade variety, 16·8% natural water content + 12% addition of water

No.	Dosage of UT 11975b in g/kg	I			II			III			IV			V		
		Average figures, based on 100 caryopses														
		emerged plants						fresh weight of shoots			non-emerged plants					
		on 7th. day			on 14th. day			on 14th. day			weakly sprouting			swollen seedlings		
		1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.	1st.	2nd. sowing	3rd.
A. Pre-storage seed treatment																
1	0	80·0	16·5	0	87·0	40·0	0	8·94	2·52	0	0	5,5	0	0	0	0
2	2	80·0	10·0	0	91·5	59·5	0	10·34	3·81	0	1·0	2·5	0	0	0·5	0
3	4	72·5	0	0	89·5	41·0	0	9·45	1·99	0	1·0	5·0	0	1·0	0	0
4	6	62·5	0	0	88·0	2·5	0	8·22	0·03	0	0·5	5·5	0	3·0	4·5	0
5	8	40·0	0	0	82·5	0	0	7·20	0	0	0	0	0	6·5	1·5	0
6	10	25·0	0	0	63·5	0	0	4·76	0	0	0	0	0	13·0	0·5	0
B. Post-storage seed treatment, and back-drying to 12·6% (2nd. sowing) and 11·1% (3rd. sowing) water content, respectively																
1	0	—	1·0	0	—	21·0	0	—	1·20	0	—	2·5	0	—	2·0	0
2	2	—	0	0	—	24·0	0	—	1·42	0	—	2·5	0	—	2·5	0
3	4	—	0	0	—	27·5	0	—	1·63	0	—	5·5	0	—	1·0	0
4	6	—	0	0	—	27·5	0	—	1·39	0	—	4·5	0	—	2·5	0
5	8	—	0	0	—	24·5	0	—	1·09	0	—	1·5	0	—	1·0	0
6	10	—	0	0	—	15·0	0	—	0·54	0	—	3·0	0	—	2·5	0

Discussion of results

The following points are evident from Tables 1 B—8 B in comparison with the first sowing operation (values for this are given under A):

The seed stored in an untreated, dry state (Table 1) is unchanged in the second and third sowing operation, as compared with the first sowing operation. Post-storage treatment carried out immediately before the seed is sown, has a favourable effect on the number of plants and the plant mass in comparison with untreated seed, that is at overdosages of up to five times the standard dosage. Compared with normally treated seed, a multiple overdosage causes only a slight retardation of emergence.

For seed with a water content of 16·8 % which is only slightly above the normal water content, no change is evident in the second sowing of seed after 17 days' storage as compared with the first sowing. In the third sowing after 7 weeks, a slight retardation of emergence and a reduction of the germinating capacity are noticed. The reaction to seed treatment is the same as for seed stored dry — essentially positive, slightly inhibiting at multiple overdosages. A drop in the rate of germination and the germinating capacity is established for all untreated seed stored with contents of water ranging above 16·8 %; this drop is undoubtedly above the tolerable limit, and its extent depends solely upon the degree of moisture and the duration of storage. There is no indication of increased susceptibility to normal or overdosed seed treatment.

Tables 1 A to 3 A, of which Tables 1 A to 4 A (including test groups 1 to 3) are of special practical importance, reveal the following:

A normal treatment of seed with CERESAN Universal Dry Seed Dressing, carried out before storage, has a favourable effect irrespective of the moisture content of the seed and the duration of storage. In fact, harm due to moisture is generally lessened slightly as the result of seed treatment. Overdosages have a much stronger effect in pre-storage treatments than when the treatment is carried out immediately prior to sowing. A double overdosage caused only insignificant germination depressions in seed stored dry. On the other hand, the damage to wet seed is considerable even when it has a water content of only 16·8 %.

Checks on the smell of stored seed showed that the smell was perfectly normal for all seed stored dry whether treated or untreated. After only two weeks of storage, moist seed already had a slight musty smell, that is when it had not been treated. But even treated seed had a musty smell following 7 weeks of storage. After the same period of storage, seed with a water content of over 20 % had a marked acidulous smell (acetaldehyde and alcohol), in addition to the mouldy smell.

Summary

Storage tests carried out with winter wheat seed of the Carstens VI variety, which was subsequently sown in sand, showed that

1. moist seed is not storable — damage increases proportional to the content of moisture and the duration of storage;
2. the susceptibility of seed to CERESAN Universal Dry Seed Dressing is not influenced by moist storage — damage caused by moisture cannot be reme-

died by the seed treatment, but on the other hand it is not made worse by subsequent treatment;

3. a pre-storage treatment of seed that is properly carried out tends to lessen damage due to moisture rather than increase it — on the other hand, overdosages applied in the pre-storage treatment are far less tolerated by wet seed than by dry seed.

An exactly dosed dry treatment carried out with CERESAN prior to storage can be recommended in all cases even when the water content of the seed is uncertain.

Pineapple Mealybug Control in Taiwan

by Gideon Ting-wei Lew
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September, 1957

The pineapple mealybug *(Dysmicoccus brevipes* Ckl.) attacks a number of horticultural pests in Taiwan. This pest, however, is chiefly destructive in pineapple crops due to the toxicogenic role it plays in the pineapple mealybug-wilt complex.

Research conducted by Carter and co-workers in Hawaii constituted an appreciable contribution to the knowledge of this intricate pest problem but there is no concrete information available on how to carry out an economic control of the pest. Following extensive trials and research work lasting over a period of several years entomologists in Taiwan finally succeeded in developing a practical control method adaptable to local conditions. The practice recommended to give control of the mealybug may be outlined as follows:

1. Before being planted out, seedlings are dipped in a solution of FOLIDOL E 605® Emulsion to make sure that the planting material is free from infestation by mealybugs or other pests.

2. During the first 8 months of growth, the plants are given three applications of a FOLIDOL E 605 solution which is poured into the centre of the leaf whorl. In addition, the surrounding soil should be treated with insecticides to kill or repel ants.

In order to keep the ratoon crops clean, it is imperative that the plant crop is effectively protected against mealybug infestation. In new orchards adjoining old plantations, the most economic way of affording the ratoon protection is to apply a soil insecticide along a 2 metre wide strip of soil between the old and the new plantations; this border strip will then constitute an effective barrier zone against migrating pests. "Spot treatment" with a FOLIDOL E 605 solution should be carried out wherever symptoms of infestation are detected.

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Treatment should be given not only to wilting plants but also to adjoining plants. The rate of application should not exceed one litre of FOLIDOL E 605 emulsion per hectare. Data obtained from trial controls of mealybug carried out between August 1954 and August 1957 show that the rate of mealybug-wilt in the test fields ranged from 0·021 to 0·29 percent, and that the yield of the first ratoon crop amounted to 10·97 metric tons (25,000 seedlings per hectare) as against 4·5 metric tons in the check field. In these test fields, only two instead of three applications of FOLIDOL E 605 were carried out in the period between August 1954 and April 1955, indicating that dipping in Parathion and the reduced number of FOLIDOL E 605 treatments made during the first eight months of growth grave effective protection to the both the plant crop and the first ratoon crop. This point is rather important and will be discussed later.

The laboratory and field tests carried out from 1952 to 1956 provided a large source of information which proved to be of great value for the development and planning of the control method. Summarized briefly, these tests brought to light the following facts:

1. For killing mealybugs on the plant, thirteen kinds of organophosphorus compounds were subjected to a series of toxicological tests. FOLIDOL E 605 (diethyl-p-nitrophenyl thiophosphate 46·7 % W/V emulsive concentrate) was selected from among the parathion emulsions for its reliable and somewhat selective action at a low concentration.
2. In these tests, the more widely known systemic insecticides, including SYSTOX ®, did not by any means produce an effect superior to that given by FOLIDOL E 605.
3. Mealybugs contacted by FOLIDOL E 605 showed symptoms typical of poisoning by an organic lipophile contact insecticide. The mealybug dies slowly but the dermal secreting function ceases immediately after the contact poison becomes effective, rendering the pest unattractive to ants.
4. The control of ants is indispensable to the economy of mealybug control. It was established in the tests that a treatment of the soil surface with insecticides gave better results than a treatment in which the insecticide is worked into the soil.
5. The results obtained in application-date tests showed that it was necessary to rearrange the control operation schedule, at the same time making for greater economy.

In tropical Taiwan, this ovoviviparous mealybug species breeds all the year round. The injuries which the pest inflicts are usually slighter in new plantations but the degree of wilt spread may vary considerably among plantations in the same locality due to such factors as the origin of planting material, cultural practices, condition of soil and drainage etc. The development of a mealybug colony in a field is, however, greatly influenced by climatic factors, because in South Taiwan the transition between the rainy season in Summer and the dry season from Autumn to Spring is constant and well marked. The downpours at the beginning of the rainy season in May actually wash away and destroy a large number of the summer offspring,

thus reducing the spring population appreciably. The rise of population, at the end of the wet season, is abrupt and sharp, attaining its annual peak in late September. In a five-year production cycle, the seedlings are customarily planted in August, just before a season that favours intense mealybug reproduction, so that the initial population on the crop continues to grow until

Fig. 1: Healthy pineapple plant alongside a plant infected by pineapple wilt in the foreground

reduced by rain in the following year. Afterwards, however, the population soars again and reaches its next peak in the following Autumn; from then on, provided the weather is normal, multiplication continues at a high level. At this time, infestation is seemingly widespread although no distinct symptoms of plant wilting appear until after the arrival of rain in the following year, namely the 3rd year in the cycle. The rapid collapse of plants attacked

in the wet season, following serious infestation, may be attributed to the following factors:

a) physiological degeneration of the plants due to prolonged mealybug feeding

b) attacks by secondary organisms at this time.

These two factors can hasten the complete destruction of the plants. The percentage of wilting plants is always much lower than the percentage of plants infested by mealybugs, indicating that plant wilting is also influenced by other factors. It is also in the rainy season that large numbers of migrating "crawlers" are to be observed swarming over the emerging fruit stalks; later, these crawlers settle on the fruits and slips. The crop can be rid of a considerable proportion of its pests by picking the infested fruits and slips in July and August. But as soon as the dry season commences, the new colonies in the field concentrate their attacks on the emerging suckers, in other words the plants of the ratoon crop. The dry conditions prevailing during the long winter months not only enhance mealybug infestation but also suppress the growth of the suckers. This accounts for the fact that the mealybug-wilt destruction is more pronounced in the ratoon crops. It is the failure of the ratoon crop that deprives the grower of his profit. The total investment made by a farmer in South Taiwan, in a five-year production cycle amounts to NT$ 15,397 per ha. During the first three years, NT$ 12,118 have to be spent representing 78·80 % of the total investment. A good plant crop in the first harvest produces about 60 % of the total fruit yield obtainable in the five-year cycle. But this gives the farmer no assurance that he will not suffer a loss in the end. His investment is not secure unless the good plant crop in the first year is followed by a healthy ratoon crop which constitutes the major part of his profit. Therefore, a mealybug-wilt control operation can hardly be considered as really successful if it does not afford economic protection for both the plant crop and at least the first ratoon crop. Ultimately, a grower will assess the value of a control operation according to whether or not it brings him a rich and rewarding ratoon harvest.

The work entailed to familiarize local growers with the recommended control method, consists of

a) designing and supplying simple type equipment for the safe handling of the toxic chemicals, and

b) grouping growers to form "Pineapple Pest Control Teams" in the different pineapple-growing districts so that they can procure pesticides and share equipment not readily available.

Courses were conducted to train the team-leaders. These leaders were responsible for passing on to their groups necessary technical information, and supervising work in the fields, tasks which they performed most efficiently.

The equipment for the dip treatment in FOLIDOL E 605 solution consists of four screen-bottomed tin-plate cradles (two of which are slightly smaller so that they can be placed in the two larger ones to save space during transport) for holding the seedlings, and a tin-plate trough for the chemical. The seedlings are tightly packed in the cradles, with their leaves pointing upwards. The packed cradles are then lowered into the FOLIDOL E 605 solu-

tion (1:1000) for two minutes, after which they are lifted out, and placed upside down on a tilted stand. Being tightly packed, the seedlings will not fall out, but all excess liquid not taken up by the seedlings can be drained off and fed back to the trough. The cradles are then removed from the stand by a swinging motion, and the seedlings are tipped out on to the ground with their leaves pointing downwards to facilitate complete drainage of the chemical, thus ensuring safety in handling. The operators wear rubber gloves, boots and aprons as a safety precaution.

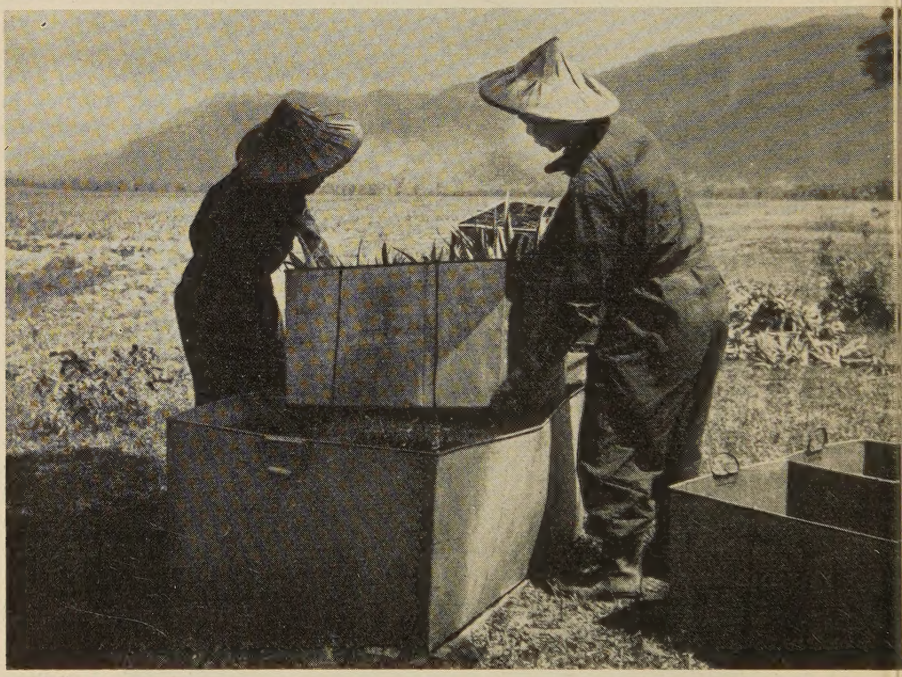

Fig. 2: Pineapple seedlings are dipped in the FOLIDOL E 605 solution, tightly packed in a screen-bottomed tin-plate cradle

The equipment for preparing the solution consists of a 40 gallon tin-plate drum provided with a simple type hand-operated agitator. The stock solution is measured out by means of a graduated cylinder and poured into the water in the drum, with the agitator constantly in motion to stir the solution thoroughly. The solution is then siphoned through a rubber tube into tin-plate pails. These filled pails are then passed on to the workers who are equipped with measuring cups fitted to the end of rods to dosage out the solution and pour it into the leaf whorls of the plants. To avoid contact with the solution, the workers start the application from the end of the rows in the direction of the wind, and then pace backwards against the wind. By walking between the rows, one person can treat the plants in two neighbouring rows. For protec-

tion, the operators need no more than a pair of rubber gloves and a pair of rubber-soled canvas shoes.

The extension training programme of field demonstrations was started at a number of contracted farms. The trial controls were carried out by extension service teams of experienced technicians. As soon as the good results obtained in the test fields stood out distinctly as compared with the untreated check fields, the growers from neighbouring localities were invited to visit

Fig. 3: FOLIDOL E 605 solution is poured into the leaf whorls of the pineapple plants

the demonstration fields; talks were given by the technicians who also answered questions put forward by the growers. The names were then registered of all growers who expressed their willingness to try out the control method in their own fields. Owners of 10 hectare orchards in collective areas were grouped to form working-teams. A complete set of equipment and protective

gear together with half the required quantity of pesticides were donated by the government to each team.

The members of a team work cooperatively, sharing the use of allocated equipment and material, and they keep strictly to a time schedule mutually agreed upon. Travelling expenses are also provided to enable extension service technicians to visit the teams and give them practical assistance and advice.

When the controls carried out in these plantations give good results, the success of the operation will thus be fully demonstrated to all those interested. Volunteer teams organized in the same localities after this first trial will pay four-fifths of the costs incurred by the control, but technical advice and assistance will still be given by the government free of charge.

The extension programme was started in 1954. In a period of three years the recommended control method has been adopted in pineapple plantations covering an area of more than 2,300 hectares. The rate of infestation in treated fields where growers have adhered strictly to the instructions given, is below 0·2 % or even nil. The simple type equipment used has guaranteed safe handling of the chemicals; not a single accident was reported up to August, 1957.

The author is of the opinion that the success of pineapple mealybug-wilt controls depends upon a timely and effective suppression of the initial pest population colonizing the crop. Even though a minimized colony on a vigorous plant may not necessarily cause this plant to wilt, a complete elimination of the pest should nevertheless always be the goal of every field control operation. In South Taiwan, a thorough disinfection of seedlings before planting is of fundamental importance to economic control. All supplemental treatments must be completed before the arrival of the season which favours intense multiplication of mealybugs, in other words within the first year of crop growth. Furthermore, it is essential to carry out to the letter and most efficiently all cultural practices necessary to keep the growing crop in healthy condition. If this is not done, it will be found most difficult to control the infestation and prevent damage being inflicted solely by the application of pesticides. The reasons for this are as follows:

1. inaccessibility of chemicals to pests concealed under the thick, shielding leaves, and
2. the change involved in the physiological condition of both the pest and the host plant — a biological phenomenon explored by C a r t e r and his co-workers in recent years.

The mealybug-wilt control programme as adopted in Taiwan may differ from schemes in other countries. But it testifies how invaluable the findings are which were made during the course of the pioneering work conducted in Hawaii; these findings should remain the guiding principles of pineapple mealybug-wilt control.